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Interactive Comment

Interactive comment on “Non-linear statistical downscaling of present and LGM precipitation and temperatures over Europe” *by* M. Vrac et al.

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The aim of the manuscript is to develop a statistical downscaling model to estimate regional climate changes from the the low-resolution climate model CLIMBER. The predictors in this statistical model are a combination of purely geographical factors (position), geographical-physical factors (continentality) and purely physical factors (entirely simulated by the CLIMBER model). The predictands are monthly or yearly temperature and precipitation. The statistical model is somewhat unusual in the context of statistical downscaling: first, the predictors and predictands are the climatological values at each grid-point and the samples are the different grid-points. Second, the statistical model itself is non-linear, constructed upon fitting cubic splines. And third, the predictors are taken directly from a climate simulation, instead of estimating the parameters of the statistical model with purely observational data sets The statistical model is then

EGU

tested by applying it to North America in the present climate and tested in in Northern Europe in the Last Glacial Maximum.

Unfortunately, I see a series of quite problematic aspects in the statistical approach, which I try to explain below, followed by comments on more particular points.

1. The choice of predictors seems to me quite strange. What is the role of the purely geographical predictors?. These predictors will essentially remain unchanged in the past or in the future 8218;Äì with the exception of elevation change and distance to the ocean due to changing sea-level. Therefore, as the authors point out, they will not contribute to produce any changes in the estimated temperature or precipitation, unless the statistical model includes non-linear coupling terms between the predictors. As far as I understood, this is not the case in this model. The possible influence of the geographical predictors is even not really meaningful. For instance, elevation will increase in the LGM because of a lower sea-level. The statistical model will interpret this elevation change as a mean cooling proportional to the current lapse-rate. I do not think this is meaningful: the mean cooling in the LGM is caused by other quite different factors. There are some awkward sentences related to the geographical predictors. In section 3.3, longitude is found to improve the explained variance, but their contribution is generally very flat, so that it is disregarded as predictor. This is very confusing: either it is an important predictor or not.

2.I am afraid that the number of free parameters in the statistical is large. In the annual model, 8 predictors are used, but from the manuscript it is unclear how many splines along the whole predictor range have been fitted. Assuming that, say, 4cubic splines have been used as in the example in figure 1, without no derivative-matching at the edges, we have 12 free parameters per predictor, totalling 96 free parameters. The number of CRU grid-points in the geographical region may be around 200. The ratio number of parameters to number of samples is clearly quite dangerous, and it seems to me quite likely that the model has been overfitted. The manuscript should give much mode detailed description of these technical details of the model. The number of pre-

CPD

3, S537–S541, 2007

Interactive Comment

dictors used in the model is selected according to the Bayesian information criterion (eq. 6), in which the mean square error plus a term penalizing the number of predictors, is minimised. However, unless I am missing something here, this equation is not well defined. The two terms in equation 6 have different units ($K^2 or$(mm/month)^2 for the first, and dimensionless for the second). This means that the minimum of eq 6 will depend on the units of temperature (e.g. Kelvin or mili Kelvin) or precipitation (e.g. mm/month, or mm/day). This is obviously not meaningful. The first term in eq. 6 hast to be somehow made dimensionless, probably by dividing by the variance of observations.

3. When the statistical model is tested in North America, its performance cannot be considered satisfactory. For temperature, it seems obvious that predicted temperatures of the order of 120C to 220 C are meaningless. The residuals of the log of precipitation (are more difficult to assess ,which units? mm/year?) cover the range -6 to +2, i.e. they can be potentially also quite large. The authors conclude that the model cannot be applied out of the calibration range, but it is not clear to me how far can the physical predictors in North America be out of the European calibration range. Can this justify estimated temperatures of more 120 C? I think this caveat points more strongly to deficiencies in the statistical model, and, as I indicated before, to a likely overfitting of the model to the European data. As it is, the statistical model remains unvalidated with independent data, and as such, the suspicion will always remain that the high skill in the calibration is artificial.

4. When the model is applied to the LGM, it is either not clear whether the statistical model performs better than CLIMBER when compared to proxy-based reconstructions of T and P. The authors indicate that for some locations this is true, for others locations this is not the case. Only when two locations excluded a posteriori from the analysis, is the performance of statistical model better that the raw output of CLIMBER. This exclusions is , however, not permissible to asses the performance of any statistical model.

Particular points: 5. Throughout the manuscript, please pay attention to expressions such as smallscale, largescale. wellknown, etc. At least in my version they appear merged.

5. Abstract, the expression wslope is confusing here.

6. Introduction: It is in my opinion too long and not informative enough. Too much space is used to general considerations about statistical downscaling. I would use this space to describe the differences in the present statistical approach to more usual downscaling applications and, more importantly, to describe in a technically more detailed way the statistical model (an appendix would also do)

7. Introduction: That statistical downscaling assumes that the statistical links remain unchanged in other climates also applies to the present statistical model.

8. Section 2, end: The contribution of the LAT spline is uninformative. Why? The spline is almost linear, but it clearly contributes to the explained variance. Also, in the toy model it is strange that the contribution of the humidity to precipitation variability is not monotonously increasing. Is there any physical explanation for this, or it is the result of artificial overfitting to the data?

9. Section 3, please state the hight at which the predictors are taken, Q, RH, T, u,v, Td and Dtd

10. Section 3, why use Dtd? it is a linear combination of T and Td. It does not include any new information. This predictor is completely co-linear to the others, and its use only contributes to increase the uncertainty in the model parameters.

11. Section 3. which is the uncertainty in the model parameters, and therefore in the final estimations? Nothing is said about this.

12. Section 3, the continentality index is defined to be in the range (0,1). However I_0 and U_0 are defined as the distance and wind velocity that would make a change in the continentality index of 2. This is strange.

CPD

3, S537–S541, 2007

Interactive Comment

13. Section 3.3 'In general, we see that... the geographical predictors are more robust than the physical variables..'. What is the meaning of 'robust' here? The authors mean probably that the contribution of the geographical predictors to the estimated T and P remains almost the same in the present climate than in the past climate. This is obvious, since they remain essentially unchanged. The authors state the same idea in the following paragraph, when they acknowledge that the geographical predictors by themselves are not enough to produce changes in the predictand, and that physical predictors have to be included. My impression is that, in the end, almost all estimated changes are brought about by the physical predictors, which are essentially an interpolation of the coarse CLIMBER grid to the CRU grid.

14. Fig.1, 3, 4, 5, 6, 7,9, indicate units

Interactive comment on Clim. Past Discuss., 3, 899, 2007.